

AGENDA ITEM III C

PROPOSED NEW ACADEMIC PROGRAM

LOUISIANA TECH UNIVERSITY

BACHELOR OF SCIENCE IN NANOSYSTEMS ENGINEERING

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BACKGROUND INFORMATION

Louisiana Tech University is proposing a baccalaureate program unique to the state and nation that will utilize Tech's combined laboratory facilities and interdisciplinary research, education and support programs in the College of Engineering and Science. The proposal was initially subjected to a mail review by Noel C. Macdonald, Ph. D., Fred Kavli Chair for Microelectro Mechanical Systems (MEMS), Professor of Mechanical and Environmental Engineering and Professor of Materials, University of California at Santa Barbara. At the institution's request, Dr. MacDonald was brought to the campus in November 2004, for tours of the facilities and visits with faculty, students and administrators.

STAFF ANALYSIS

Basic information about the proposed program is provided, followed by excerpts from the consultant's report (in italics) which are juxtaposed with the institution's response to the report, where appropriate.

I. Description

Distinct engineering disciplines are identified primarily by the types of problems that professionals address (e.g. biomedical engineers address medical or health care problems, civil engineers address infrastructure or environmental problems, etc.). In addition to a strong, early foundation in integrating science, engineering and mathematics fundamentals, Nanosystems Engineering (NSE) will be distinguished by addressing problems of technology at the molecular and nanoscale level. The undergraduate degree will need a progression of "nanosystems engineering" courses which will provide students with understanding and practice in relating engineering and science topics to nanoscale problems.

The proposed program is distinct from traditional engineering or science programs in the following respects:

- NSE builds bridges between micro and molecular biology (study of nanostructures and devices assembled by nature) on the one end and modern materials science and nanotechnology (study of nanostructures and devices assembled by humans) on the other.
- NSE fosters collaborations among faculty and students with diverse backgrounds. Emerging areas such as protein engineering demand such collaborations.

- NSE will also provide a framework for collaborations among the specialists mentioned above and computer scientists and mathematicians in areas such as bio-informatics and combinatorics, thus enhancing Louisiana Tech's ongoing research and development efforts in information technology.

A. Curriculum Development Plan

Initial planning has resulted in the following guidelines for the new B.S. in Nanosystems Engineering (NSE).

1. The new degree will use [COES's] existing, common integrated freshman and sophomore engineering curriculum, but with new instructional modules developed to introduce nanosystems into these courses. As a result, students in all engineering disciplines will gain some understanding of nanosystems science and engineering.
2. Existing microsystems and nanosystems courses (e.g., MSE 404, 406), will be offered to junior students as a foundation in the discipline. Other existing courses in materials science, advanced chemistry and physics will also be utilized, with the addition of newly developed instructional modules pertinent to nanosystems.
3. A total of five new courses at the introductory (sophomore), capstone (senior design experience), and research (laboratory or internship) levels will be developed.
4. The NSE curriculum will include at least 12 hours of engineering concentration, to be selected from existing engineering discipline courses. Additionally, 6 hours of technical electives will be selected from a wide variety of choices.
5. The NSE curriculum will provide research experiences for all students in the major.
6. Undergraduate students at Louisiana Tech may take up to twelve hours of graduate credit. Consequently, NSE students can complete the BS degree in four years with credit for graduate courses. During their fifth year, these students could complete twelve additional hours of graduate credit and the thesis requirements to receive the M.S. degree.

Consultant's Report:

The basic concept of the program is great....[The] degree in NanoSystems Engineering with strong basics, laboratory experience and system components. The program description provides good lecture/laboratory experiences for the students....The organization of the interdisciplinary program management is adequate and well planned....The department chairs and faculty provided strong letters that document their support of the nano-systems program. They are ready to commit resources - faculty, staff and laboratories to fully support an upper division undergraduate Nanosystems Engineering degree.

B. Novel Approaches to Engineering and Science Education at LA Tech

In 1996 the College of Engineering merged with the School of Sciences to form the College of Engineering and Science (COES), which immediately implemented a major organizational restructuring. The resulting environment is conducive to change and has promoted strong collaboration between the engineering and science programs, as evidenced by dramatically increased research productivity as faculty have begun to work in interdisciplinary teams.

1. Integrated Engineering Curriculum - Recent collaborations between engineering and science faculty have led to significant curricular reform. In 1997 LA Tech began a pilot program for an integrated freshman and sophomore engineering curriculum (IEC) which was structured such that each quarter students take an engineering class that is directly connected to a corresponding math and science class. The engineering classes were developed to cover fundamental engineering topics as well as basic communication and computer skills, teamwork skills, and a hands-on design project. Major revisions were made in the math and science courses to more effectively align the topics in those classes with each other and the engineering topics. In the resulting offerings, all classes reinforce each other.

The pilot program showed a significant increase in retention from the freshman year to sophomore year and dramatic improvement in student performance as measured by grades in target courses. Other less direct measures, including student attitude and faculty satisfaction were also very positive. The results of the IEC pilot program helped LA Tech obtain NSF Action Agenda funding in 1999 to fully implement the program and provide training to include new faculty in teaching the IEC.

As the IEC has evolved, it has become one of the institution's primary recruitment tools for prospective engineering students. Success of the IEC has been reported in a number of measures, including performance in subsequent math and engineering courses, retention, etc., and is considered partly responsible for the increased enrollment of approximately 200 undergraduate students in COES during the ten year period between 1992 and 2002.

2. Integrated Science Curriculum - In 2002, the math and science faculty who were involved in teaching in the IEC began planning an Integrated Science Curriculum (ISC). ISC includes courses in math, chemistry, physics, computer science, and geology are offered from the COES. Math/science education courses and biology courses are offered by the Colleges of Education and the College of Applied and Natural Sciences respectively. The ISC was piloted in fall, 2002. Several math, education, and science faculty secured funding from NSF in June 2003 to more fully develop this curriculum.
3. Additional Academic Innovations at Louisiana Tech -
 - Research experiences for undergraduates (REU; NSF-funded REU in micro and nanotechnology)
 - Minority Engineering Program
 - Novel tutoring programs

- New courses in entrepreneurship
- NSF-sponsored GK-12 Teaching Fellows Program

C. Program Advisory Committee

Currently, all academic programs in the COES have Advisory Boards which participate in outcomes assessment and overall program evaluations. The Nanosystems Engineering Advisory Board (NEAB), whose members will be recruited from industry, academia, and government, will review and evaluate the curriculum plans, proposed course outlines, and suggested course modules. The NEAB will also assist in identifying appropriate capstone projects, and establishing internships and employment opportunities.

II. Need

The NSF Workshop on Societal Implications of Nanoscience and Nanotechnology recommends more and broader exposure to science in undergraduate engineering programs. An undergraduate degree is required to ensure a trained professional workforce because there is a growing trend for Americans to avoid graduate school; this results in continued dependence on foreign nationals for the technology workforce needs.

A 2002 NSF Workshop on Nanotechnology Undergraduate Education confirmed that there was no existing nanotechnology or nanoscience undergraduate degree program in the U.S. at the time and provided many practical suggestions for the development of courses and curricula.

A 2003 draft report from the National Science Board Task Force on National Workforce Policies for Science and Engineering recommended that the federal government direct substantial support to undergraduate science and engineering education in order to increase the number of US citizens in technology industries.

The proposed new interdisciplinary program is designed to meet the workforce and technological needs of the United States as defined by the National Nanotechnology Initiative (NNI) needs by preparing graduates with knowledge and skills in integrating basic nanoscale science with engineering fundamentals.

Consultant's Report:

Nanotechnology and nano-systems address a very broad industrial, defense, and medical technology base. The nation and industry are supporting and funding the growth of nanoscience and nanotechnology. Industry has great incentives to develop and commercialize nanosystems.

III. Students

The proposed NSE program will initially be offered to students enrolled in COES who have completed the first and/or second year of the IEC. Freshmen students must be prepared to take college level chemistry, English and an introductory calculus class. The program will be offered as an honors curriculum within the COES. Admission into the NSE program will be based upon academic qualifications and a communicated interest in nanosystems. Enrollment will be limited to the top applicants as determined by GPA and/or ACT. The projected enrollment and

graduates for the first five years of the proposed program are shown in the table which follows.

	Year 1	Year 2	Year 3	Year 4	Year 5
Seniors		18	20	25	30
Juniors	20	20	20	25	30
Sophomores	20	20	20	25	30
Graduates		18	20	25	30

As the proposed NSE program is unique and not offered elsewhere in the United States, it is expected to become a highly attractive program that could serve as a national recruiting tool for LA Tech University.

Consultant's Report:

Enrollment projections [are] realistic. ...the undergraduate students are very excited about the program and the technology.

IV. Faculty

The proposed program will utilize existing faculty as indicated below:

_____	6	Biomedical Engineering
_____	3	Chemical Engineering
	4	Chemistry
	2	Computer Science
	4	Electrical Engineering
	3	Mechanical Engineering
	2	Physics

Most of the courses that will be offered for the NSE program are already taught regularly, so no new faculty are needed for initiation of the proposed program. LA Tech indicates that faculty searches were underway in Biological Sciences, Chemical Engineering and Chemistry at the time of proposal submission. Further strengthening and enhancement will be achieved through replacing faculty members who retire or resign with persons whose training and research interests directly complement the NSE program.

Consultant's Report:

The faculty is on the 'cutting edge' of the field....The current faculty can cover the courses and create upper division, undergraduate courses in nano-systems engineering. ...the faculty strongly support the program; their letters and presentations indicate that they are very excited about the program. The faculty are up-to-date on the science and technology for the proposed range of courses....[I also] found the faculty very supportive of the University and the program. It was clear...that the University has recruited excellent faculty, "young and old."

V. Library and Other Special Resources

LA Tech indicates that its present library holdings are adequate to initiate the proposed program. However, it projects an additional \$3,000 per year for the first five years of program would be needed to augment its journal subscriptions as well as to purchase a few monographs, especially in the area of nanotechnology.

VI. Facilities and Equipment

LA Tech has indicated in its proposal that appropriate facilities and equipment exist for implementation of the program and that it has plans for augmenting what is currently available for students in NSE.

- A. Institute for Micromanufacturing (IfM) - LA Tech University's IfM is an integrated micro/nano manufacturing research and development facility dedicated to micro/nano scale technologies and systems research, education and commercialization. IfM has three components:
 - 1. the Research and Development facility at LA Tech,
 - 2. X-ray beam lines and lithography processing facility at the Center for Advanced Microstructures and Devices (CAMD) in Baton Rouge, and
 - 3. the Technology Transfer Center at the Shreve Industrial Park in Shreveport.
- B. BioMEMS Laboratory
- C. Tissue Engineering and Cell Culture Laboratory
- D. Biotechnology Laboratories
- E. Micro/NanoTechnology Laboratories
- F. Measurement and Characterization Laboratories
- G. Micro/Nanofabrication Teaching Laboratory (developed primarily to support B.S. program in NSE)
- H. Laboratories in Chemical Engineering and Chemistry
- I. New Biomedical Engineering Building (planning is underway)

Consultant's Report:

The clean room facilities are excellent. The question is the following: What subset(s) of the 'clean room' equipment will the undergraduates be trained to operate and to understand the operational principles for the equipment?

Response from La Tech:

Students in the proposed B.S. in Nanosystems Engineering will learn the operating principles for all of the following characterization techniques: optical microscopy, confocal microscopy, SEM (scanning electron microscopy), TEM (transmission electron microscopy), STM (scanning tunneling microscope), AFM (atomic force microscopy), surface profilometry electron spectroscopy, and XPS (X-ray Photoelectron Spectroscopy). They will learn the operating principles for the following fabrication techniques: nanoscale lithography, e-beam lithography, and layer-by-layer assembly.

The students will have some limited lab experience that consists of demonstrations to show their capabilities with most of the characterization techniques (which don't actually take place in the clean room). [LA Tech faculty] will provide some actual hands-on training for several of the instruments such as the AFM, STM, surface profilometry, and SEM. All of this equipment is available for instructional purposes and for research purposes. [the institution] will continue to seek additional funds for equipment that can be used exclusively for instructional purposes.

The students will also get some experience performing layer-by-layer nanoassembly in NSE 201 since it is not very difficult to carry out. They will learn to operate some additional equipment depending upon their senior design project but this will vary from student to student.

VII. Administration

COES utilizes an interdisciplinary administrative structure which facilitates rapid and successful response to issues such as curriculum development or reform. Undergraduate academic programs are led by a program chair a person in a non-administrative faculty appointment who has responsibility for updating and assessing the curriculum, coordinating student advising and recruiting, monitoring retention, assuring that degree requirements are met by graduating students, assisting students with placement and seeing that resource requests flow appropriately to the COES Leadership Team (Dean, Associate Deans, and Academic Directors). Academic Directors are primarily responsible for faculty and staff workload assignments, budget allocations, and faculty evaluations, as well as strategic direction and promotion of cross-college collaboration. The Associate Deans have specific duties (undergraduate studies, research and graduate studies, and external programs, respectively). The Dean maintains a coaching role for the Academic Directors, Associate Deans, and Center Directors and works primarily in development and long-range planning. COES budgeting and administrative structure supports interdisciplinary activities and provides the flexibility to support an innovative program like the B.S. in Nanosystems Engineering. A Program Chair and Academic Director for NSE will be named. Hence, the proposed program will not affect the present administrative structure of the institution.

Consultant's Report:

The proposed program and the management structure convinced [the consultant] that the structure is appropriate.

VIII. Accreditation

The existing programs in Biomedical, Chemical, Electrical, Industrial and Mechanical Engineering within COES have been awarded specific programmatic accreditation by the Accrediting Board for Engineering and Technology (ABET). NSE will seek ABET accreditation under the general engineering criteria. ABET has a base fee of \$2,650 for an accreditation campus visit plus an additional fee of \$2,650 per program that is evaluated. This additional fee would be necessary for pursuing ABET accreditation of the proposed Nanosystems Engineering program. ABET charges an annual maintenance fee of \$235/ base campus fee plus \$235 per accredited program fee.

ABET requires that educational objectives and educational outcomes are evaluated periodically. Some of these objectives can only be assessed by graduates of the program; at least one class of graduates is required before an accreditation review can be requested. If the first NSE class enrolls in the fall of 2005 as sophomores, they should graduate in the spring of 2008. LA Tech would seek accreditation for NSE in the fall of 2008, with the request that ABET would approve a site visit in conjunction with the engineering technology review.

IX. Related Fields

As the proposed program is truly interdisciplinary, its relationships with other fields has been discussed at length in the “description” section.

X. Costs

No specific budget was included in the proposal; the University indicated, however, that additional costs to implement the program would be minimal. Any new faculty hired to enhance the program will be replacements for retirements and resignations within the College. Most of the laboratory equipment needed to support the program is already present. External support for the additional equipment is already being sought through grants.

LA Tech and COES will be responsible for the costs of having an additional program reviewed for accreditation by ABET as well as additional expenditures for library acquisitions needed to support the NES program.

Consultant's Report:

Nanotechnology education is expensive; it requires ongoing financial and staff support and the ongoing updating of equipment and facilities. The funding of the program does not appear to be adequate.

The laboratory program builds on present undergraduate microelectronics and MEMS lab. The administration noted that the new clean room facility would also be used for undergraduate labs in nano-systems. However, only \$200,000 has been committed to the program. A more reasonable amount would be \$1-\$2 million with additional equipment donations.

There appears to be good [external] support to increase the access to modern laboratory facilities. I would recommend writing an NSF equipment proposal to increase the resources for

the Nanosystems Engineering undergraduate laboratory. The emphasis should be undergraduates and nano-systems education. Show detailed photographs of the present clean room and equipment with undergraduates operating the equipment. I think you have a strong case here, so make sure you show that you already have the clean room to house the new equipment. Also, you may want to promote sending some of your undergraduates in the Nano-Systems program to NSF supported nanotechnology labs at other universities - Cornell, Stanford, University of California at Santa Barbara, etc. NSF provides the support for students.

Response from La Tech:

The interdisciplinary administrative structure, which was commended by the reviewer, assures that instructional expenses for all degree programs are met by the college-wide routine expense budget. Academic units in the College of Engineering and Science (COES) do not receive separate budgets. After routine expenses are budgeted (approximately 50% of the COES budget), remaining funds are budgeted for strategic initiatives and specific academic programs. The COES routine expense budget was increased by 5% in 2004-05. The new Nanosystems Engineering degree is a priority for the COES and that priority will be reflected in its budgeting process. University funding coupled with external grant funding will be directed to provide sufficient support for the program.

While it would be an advantage to have duplicate and separate nanosystems instructional equipment which is not also used for research (as [has been] done in the new \$200,000 Microsystems Engineering lab), it is not necessary. The equipment that is currently available is state-of-the art and adequate for laboratory instruction for the new program. The use of the equipment has been committed to the new degree.

[LA Tech] will continue to seek funds for additional equipment that could be used exclusively for instruction. Since the reviewer's visit, [the institution has] received notification that one of the faculty members has been awarded an NSF CAREER grant in the area of modeling of molecular systems. This grant will also produce an undergraduate course called "Introduction to Nanobio Systems Simulation" and provide over \$50,000 in new computers and molecular simulation software. The College has also provided \$100,000 to purchase a new Atomic Force Microscope, which will be used for research and education.

Staff Note:

The institution's response indicates its intentions to submit the grants which follow and that approval of the proposed degree by the Board prior to submission of these proposals will make them more competitive for funding.

NSF MRI proposal ("Acquisition of a Field Emission Scanning Electron Microscope for Nanotechnology Research, Training, and Education") by January 27, 2005,
NSF Nanotechnology Undergraduate Education (\$200,000) proposal by April 6, 2005,
NSF IGERT (graduate training in Microsystems/Nanosystems) pre-proposal by 2/04/05
Department of Labor workforce development proposal by February 2005
BORSF enhancement proposal by October 2005.

STAFF SUMMARY

The proposed NSE program is unprecedented and responds to a nationally documented area of need. La Tech has capitalized upon its strength and experience in interdisciplinary science and engineering curricular design and research. The NSE curriculum is appropriate. Administrative support for the program is established. Faculty with expertise as well as teaching and research interests are present. Facilities are adequate to implement the program. Opportunities for additional extramural funding are excellent.

The staff wishes to complement the faculty, staff and administration of LA Tech University for the development of this novel undergraduate offering and encourages the institution to take full advantage of the opportunities that the NSE program offers for recruiting and obtaining grant awards available to such an innovative bachelor's level program. The staff advises, however, that ongoing support from the faculty, staff and administration as well as a continuing high level of external funding and curricular refinement will be needed to maintain a program of excellence. Hence, reporting addressing these concerns until ABET programmatic accreditation has been achieved is appropriate.

STAFF RECOMMENDATION

The staff recommends that the Academic and Student Affairs Committee grant conditional approval for the Bachelor of Science in Nanosystems Engineering (CIP Code 14.9999) at Louisiana Tech University to be implementation beginning fall 2005. By September 1, 2006, and annually thereafter until ABET accreditation has been accomplished by the program, the institution shall submit to the Commissioner of Higher Education a report documenting efforts to secure external funding for equipment acquisition and additional support of the program.